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(54) **APPARATUS FOR DETECTING DAMAGE IN BEARING**

(57)Abstract:
PROBLEM TO BE SOLVED: To establish techniques for detecting the occurrence of damage caused by metal fatigue and the catching of foreign matter, specifying the location of the damage, and determining the development of the damage in a bearing provided for a large-scale rotating machine such as an air preheater.
SOLUTION: Two AE sensors S1 and S2 are installed to the bearing 1 at an interval to each other to create a difference signal between their output signals. In the case that a variation exceeding a threshold value present in the difference signal is detected, it is recognized that acoustic waves caused by the damage have occurred in the bearing 1.

CLAIMS

[Claim(s)]
[Claim 1]It is a damage detection apparatus of a bearing which vacates an interval for a bearing or its neighborhood, installs two or more acoustic emission sensors in it, and detects generating of damage in said bearing based on an output signal of this acoustic emission sensor, A damage detection apparatus of a bearing characterized by recognizing it as an acoustic wave which makes said damage a cause having occurred in said bearing when change exceeding a threshold which creates a difference signal of an output signal about two of said two or more acoustic emission sensors, and is in this difference signal is detected.

[Claim 2]It is a damage detection apparatus of a bearing which vacates an interval for a bearing or its neighborhood, installs two or more acoustic emission sensors in it, and detects generating of damage in said bearing based on an output signal of this acoustic emission sensor, A damage detection apparatus of a bearing recognizing it as an acoustic wave which makes said damage a cause having occurred in said bearing when a time lag was individually set by said two or more acoustic emission sensors and change of an output was detected.

[Claim 3]A damage detection apparatus of the bearing according to claim 2 having installed said two acoustic emission sensors side by side, having attached one acoustic emission sensor to said bearing soon, and attaching an acoustic emission sensor of another side to said bearing via an interval piece.
[Claim 4]A damage detection apparatus of the bearing according to claim 2 having had said two acoustic emission sensors, having estranged and arranged at least one acoustic emission sensor from said bearing, and making a substance excellent in sound propagation nature intervene between said each acoustic emission sensor and said bearing.
[Claim 5]A damage detection apparatus of the bearing according to claim 2 estranging and attaching said acoustic emission sensor to a hoop direction of at least three and said bearing.
[Claim 6]It is a damage detection apparatus of a bearing which vacates an interval for a bearing or its neighborhood, installs two or more acoustic emission sensors in it, and detects generating of damage in said bearing based on an output signal of this acoustic emission sensor, Said acoustic emission sensor is estranged and attached to a hoop direction of at least three and said bearing at equal intervals, A damage detection apparatus of a bearing recognizing it as an acoustic wave which makes said damage a cause between what detected first an acoustic wave which makes said damage a cause among said acoustic emission sensors, and a thing detected to the second having occurred.
[Claim 7]A damage detection apparatus of the bearing according to claim 6 pinpointing a generation place of said acoustic wave based on a time lag of an output of an acoustic emission sensor which detected said acoustic wave first, and an output of an acoustic emission sensor detected to the second.
[Claim 8]It is a damage detection apparatus of a bearing which vacates an interval, installs two acoustic emission sensors near the bearing, and detects generating of damage in said bearing based on an output signal of this acoustic emission sensor, Close arrangement of the predetermined interval is vacated and carried out from an inner ring of spiral wound gasket which constitutes said bearing for one side of said two acoustic emission sensors, Close arrangement of said predetermined interval is vacated and carried out from an outer ring of spiral wound gasket which constitutes said bearing while coinciding another side of said two acoustic emission sensors with said one acoustic emission sensor and a hoop direction of said bearing, A substance excellent in sound propagation nature is made to intervene between said one acoustic emission sensor and said

inner ring and between an acoustic emission sensor of said another side, and said outer ring of spiral wound gasket, A damage detection apparatus of a bearing recognizing it as said acoustic wave having occurred with parts close to an acoustic emission sensor which detected previously an acoustic wave which makes said damage a cause between said two acoustic emission sensors.
[Claim 9]It is a damage detection apparatus of a bearing which vacates an interval, installs two acoustic emission sensors near the bearing, and detects generating of damage in said bearing based on an output signal of this acoustic emission sensor, Close arrangement of the predetermined interval is vacated and carried out from an inner ring of spiral wound gasket which constitutes said bearing for one side of said two acoustic emission sensors, Close arrangement of said predetermined interval is vacated and carried out from an outer ring of spiral wound gasket which constitutes said bearing while coinciding another side of said two acoustic emission sensors with said one acoustic emission sensor and a hoop direction of said bearing, A substance excellent in sound propagation nature is made to intervene between said one acoustic emission sensor and said inner ring and between an acoustic emission sensor of said another side, and said outer ring of spiral wound gasket, A damage detection apparatus of a bearing recognizing it as said acoustic wave having occurred with parts close to an acoustic emission sensor which detected an acoustic wave which makes said damage a cause between said two acoustic emission sensors with a bigger signal level.

[Claim 10]It is a damage detection apparatus of a bearing which installs two or more acoustic emission sensors in a bearing or its neighborhood, and detects generating of damage in said bearing based on an output signal of this acoustic emission sensor, Whenever an acoustic wave which makes said damage a cause occurs, a generation place of this acoustic wave is pinpointed, It is recognized as an inner ring of spiral wound gasket which constitutes said bearing and is rotated with an axis when this generation place moves in connection with the passage of time with relative velocity of said inner ring of spiral wound gasket to said rolling element having been damaged, It is recognized as a rolling element which constitutes said bearing when a generation place of said acoustic wave moves at the rate of a half of revolving speed of said axis having been damaged, A damage detection apparatus of a bearing recognizing it as an outer ring of spiral wound gasket which constitutes said bearing and is fixed to a regular position when a generation place of said acoustic wave does not move by the passage of time, either having been damaged.
[Claim 11]It is a damage detection apparatus of a bearing which installs two or more acoustic emission sensors in a bearing or its neighborhood, and detects generating of damage in said bearing based on an output signal of this acoustic emission sensor, One point of a hoop direction is set as each of an inner ring which constitutes said bearing, a cage holding a rolling element, and an outer ring of spiral wound gasket as a reference point, Whenever an acoustic wave which makes said damage a cause occurs, a generation place of this acoustic wave is pinpointed, A damage detection apparatus of a bearing which measures a phase angle of a hoop direction from said reference point to a generation place of said acoustic wave about each of said inner ring, a cage, and an outer ring of spiral wound gasket, and is characterized by recognizing it as damage having occurred on parts from which said phase angle does not change among said inner ring, a cage, and an outer ring of spiral wound gasket.
[Claim 12]It is a damage detection apparatus of a bearing which installs two or more acoustic emission sensors in a bearing or its neighborhood, and detects generating of damage in said bearing based on an output signal of this acoustic emission sensor, Two or more fields divided into a hoop direction about an inner ring which constitutes said bearing, a cage holding a rolling element, and each part article of an outer ring of spiral wound gasket are set up, Whenever an acoustic wave which makes said damage a cause occurs, a generation place of this acoustic wave is pinpointed by each area unit of said each part article, A damage detection apparatus of a bearing integrating generating frequency of said

acoustic wave for every pinpointed field, comparing the number of accumulation for every fields of all the, and judging a grade of advance of said damage in said each part article.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to the art of detecting generating of the damage which makes a cause a bite lump of the metal fatigue and a foreign matter about the bearing provided in a large-sized rotary machine, pinpointing an injured spot, or judging the progress condition of damage.

[0002]
[Description of the Prior Art]For example, in the case of the device which has a large-sized solid of revolution like a YUNGUSUTOROMU air preheater, the large-sized thing is adopted also as the bearing which supports the axis of this solid of revolution pivotable in proportion to the solid of revolution.

[0003]In the case of the YUNGUSUTOROMU air preheater, the solid of revolution holding a heating element is allotted in the perpendicular direction in a main axis, and the upper and lower sides of the axis are supported with ******** anti-friction bearing. In consideration of the weight of a solid of revolution, large-sized self-aligning thrust roller bearing is adopted as the bearing allocated especially in the lower end of an axis.
[0004]
[Problem(s) to be Solved by the Invention]Although an air preheater is a device installed in a thermal power plant etc., since it is always working fundamentally, about the bearing of a solid of revolution, the inspection of a damaged area will be conducted during operation of a power generating plant in the case of a periodic check. However, if it does not necessarily generate before a periodic check and damage generates damage immediately after a periodic check, till a next periodic check, it will leave damage and will work, and the dangerous situation is imitated, and ******** is pointed out.
[0005]Although development of the art of detecting the abnormalities of a bearing is performed in every direction from such backgrounds, Since the mass of each part article in which the revolving speed of a solid of revolution constitutes a bearing late (about 20 rpm) to the exciting force produced by generating of damage in the case of large-sized anti-friction bearing provided in the above air preheaters is large, It is impossible to detect abnormalities from the acceleration produced in each member according to exciting force.
[0006]About the bearing which this invention is made in light of the above-mentioned circumstances, for example, is provided in a large-sized rotary machine like a YUNGUSUTOROMU air preheater. It aims at establishing the art of detecting generating of the damage which makes a cause a bite lump of the metal fatigue and a foreign matter, pinpointing an injured spot, or judging the progress condition of damage.
[0007]
[Means for Solving the Problem]A damage detection apparatus of a bearing of the following composition is adopted as above-mentioned The means for solving a technical problem. Namely, a damage detection apparatus of the bearing according to claim 1, It is a damage detection apparatus of a bearing which vacates an interval for a bearing or its neighborhood, installs two or more acoustic emission sensors in it, and detects generating of damage in said bearing based on an output signal of this acoustic emission sensor, A difference signal of an output signal is created about two of said two or more acoustic emission sensors,

and when change exceeding a threshold in this difference signal is detected, it is recognized as an acoustic wave which makes said damage a cause having occurred in said bearing.
[0008]AE (acoustic emission) sensor detects a phenomenon in which internal energy is released as an acoustic wave with solid modification and destruction, and an acceleration sensor etc. can perform damage detection, without being influenced by mass of parts which are different and constitute a bearing.
[0009]By the way, when detecting damage using an acoustic emission sensor, electrical noise generated, for example by opening and closing of a relay circuit poses a problem. An acoustic emission sensor is difficult to distinguish and detect an acoustic wave and electrical noise which generate damage as a cause on the structure. It is also difficult to distinguish background noise resulting from noise generated around a bearing.
[0010]Then, in this invention, a difference signal of an output signal is created about two acoustic emission sensors made into an object, and when change exceeding a threshold in the difference signal is detected, it is made like [recognizing it as an acoustic wave which makes damage a cause having occurred in a bearing].
[0011]Although electrical noise is detected to the same timing regardless of a setting position of two acoustic emission sensors, Since an acoustic wave which makes damage a cause spreads a bearing and reaches an acoustic emission sensor, when [which two acoustic emission sensors estranged] installed, it will be detected from both acoustic emission sensors by each acoustic emission sensor to different timing except for a case where damage occurs in a part in the equal distance. Background noise is mostly detected by every acoustic emission sensor on the level.
[0012]If a waveform of an output signal of two acoustic emission sensors is made to contrast here, change at the time of detecting electrical noise and background noise appears in a simultaneous point, and change at the time of detecting an acoustic wave which makes damage a cause will set a time lag, and will appear. Then, if a difference signal of two output signals is created, change by electrical noise or background noise will be offset, but. Since change at the time of detecting an acoustic wave which makes damage a cause is divided into positive/negative and it appears, when such waveforms are detected, it is recognized as an acoustic wave which makes damage a cause having occurred in a bearing. However, since it is also considered to be electrical noise and background noise by acoustic emission sensor that change by another factor is completely detected, a certain threshold is provided and only change exceeding this threshold is set as the object of recognition. By performing such processing, it becomes possible to detect correctly generating of an acoustic wave which makes damage a cause, without being confused by electrical noise and background noise.
[0013]As for an output signal of an acoustic emission sensor, it is desirable to precede creation of a difference signal and to process frequency restrictions (bandpass), envelope detection, etc. Since it is necessary to provide a threshold of two positive/negative in a difference signal, it is desirable by rectifying a difference signal and absolute-value-izing an output to set setting out of a threshold to one and to attain simplification of processing.
[0014]A damage detection apparatus of the bearing according to claim 2 vacates an interval for a bearing or its neighborhood, and installs two or more acoustic emission sensors in it, When it is a damage detection apparatus of a bearing which detects generating of damage in said bearing based on an output signal of this acoustic emission sensor, a time lag is individually set by said two or more acoustic emission sensors and change of an output is detected, it is recognized as an acoustic wave which makes said damage a cause having occurred to said bearing.
[0015]As mentioned above, electrical noise is detected to the same timing regardless of a setting position of two acoustic emission sensors, but. Since an acoustic wave which makes damage a cause spreads a bearing and reaches an

acoustic emission sensor, when [which two or more acoustic emission sensors estranged] installed, it will be detected from each acoustic emission sensor by each acoustic emission sensor to different timing except for a case where an acoustic wave occurs in a part in the equal distance. Then, when a time lag is individually set by two or more acoustic emission sensors and change of an output is detected, he is trying to recognize it as an acoustic wave which makes damage a cause having occurred in a bearing in this invention. By performing such processing, it becomes possible to detect correctly generating of an acoustic wave which makes damage a cause, without being confused by electrical noise and background noise.

[0016]In the damage detection apparatus according to claim 2, a damage detection apparatus of the bearing according to claim 3 installed said two acoustic emission sensors side by side, attached one acoustic emission sensor to said bearing soon, and attached an acoustic emission sensor of another side to said bearing via an interval piece.

[0017]By attaching one acoustic emission sensor to a bearing soon, and attaching an acoustic emission sensor of another side to a bearing via an interval piece in this invention, Only a part of an interval piece will estrange and arrange it in the distance rather than one acoustic emission sensor, seeing an acoustic emission sensor of another side from a generation place of an acoustic wave, It is possible to raise sensitivity as for which a part (acoustic velocity peculiar to the length/interval piece of an interval piece) lengthens time of concentration of an acoustic wave to an acoustic emission sensor of another side rather than time of concentration of an acoustic wave to one acoustic emission sensor and which detects generating of an acoustic wave. It is desirable to adopt construction material which is suitably slow to an interval piece, and has little attenuation to it. [of speed which spreads a sound] It is possible for this to emphasize further a time lag at the time of each acoustic emission sensor detecting an acoustic wave.

[0018]In the damage detection apparatus according to claim 2, a damage detection apparatus of the bearing according to claim 4 was provided with said two acoustic emission sensors, and has estranged and arranged at least one acoustic emission sensor from said bearing, and a substance excellent in sound propagation nature was made to intervene between said each acoustic emission sensor and said bearing.

[0019]By estranging and arranging at least one acoustic emission sensor from a bearing in this invention, and making a substance excellent in sound propagation nature intervene between each acoustic emission sensor and a bearing, It is possible to raise sensitivity as for which a part (acoustic velocity peculiar to a substance excellent in the distance / sound propagation nature between two acoustic emission sensors) lengthens time of concentration of an acoustic wave to one acoustic emission sensor rather than time of concentration of an acoustic wave to an acoustic emission sensor of another side and which detects generating of an acoustic wave. It is desirable to use a lubricating oil in which a bearing is dipped as a substance made to intervene between a bearing and an acoustic emission sensor. It is because it has the characteristic which speed of a lubricating oil which spreads a sound is suitably slow, and has little attenuation.

[0020]A damage detection apparatus of the bearing according to claim 5 estranged and attached said acoustic emission sensor to a hoop direction of at least three and said bearing in the damage detection apparatus according to claim 2.

[0021]When it estranges to a hoop direction and three or more acoustic emission sensors are installed, an acoustic wave which makes damage a cause is not simultaneously detected by each acoustic emission sensor. Then, in this invention, when a time lag is individually set by each acoustic emission sensor and change of an output is detected, it is recognized as an acoustic wave which makes damage a cause having occurred in a bearing. By performing such processing, it becomes possible to detect generating of an acoustic wave which makes damage a

cause, without being confused by electrical noise and background noise.

[0022]A damage detection apparatus of the bearing according to claim 6 vacates an interval for a bearing or its neighborhood, and installs two or more acoustic emission sensors in it, It is a damage detection apparatus of a bearing which detects generating of damage in said bearing based on an output signal of this acoustic emission sensor, Said acoustic emission sensor is estranged and attached to a hoop direction of at least three and said bearing at equal intervals, and it is recognized as an acoustic wave which makes said damage a cause between what detected first an acoustic wave which makes said damage a cause among said acoustic emission sensors, and a thing detected to the second having occurred.

[0023]When it estranges to a hoop direction of a bearing at equal intervals and an acoustic emission sensor of plurality (three or more) is installed in it, an acoustic emission sensor which detected first an acoustic wave which makes damage a cause, and an acoustic emission sensor detected to the second will certainly adjoin each other. It is because an acoustic wave is divided into two hands and spread from the generation place to a hoop direction. Then, in this invention, it is recognized as an acoustic wave which makes said damage a cause between an acoustic emission sensor which detected an acoustic wave first, and an acoustic emission sensor detected to the second having occurred. It becomes possible to pinpoint roughly a generation place of an acoustic wave which makes damage a cause by performing such processing.
[0024]A damage detection apparatus of the bearing according to claim 7 pinpoints a generation place of said acoustic wave in the damage detection apparatus according to claim 6 based on a time lag of an output of an acoustic emission sensor which detected said acoustic wave first, and an output of an acoustic emission sensor detected to the second.
[0025]Speed of an acoustic wave which spreads a bearing is determined by construction material of a bearing in this invention, A product of a time lag of an output of an acoustic emission sensor which detected an acoustic wave first, and an output of an acoustic emission sensor detected to the second, and speed of an acoustic wave, It is equivalent to a difference of distance to an acoustic emission sensor which detected this acoustic wave from a generation place of an acoustic wave which makes damage a cause to the second, and distance to an acoustic emission sensor which detected this acoustic wave from a generation place of an acoustic wave first. Therefore, if distance of an acoustic emission sensor detected first and an acoustic emission sensor detected to the second understands an acoustic wave, it is easily possible to pinpoint a generation place of an acoustic wave.
[0026]Near the bearing, a damage detection apparatus of the bearing according to claim 8 vacates an interval, and installs two acoustic emission sensors, It is a damage detection apparatus of a bearing which detects generating of damage in said bearing based on an output signal of this acoustic emission sensor, Close arrangement of the predetermined interval is vacated and carried out from an inner ring of spiral wound gasket which constitutes said bearing for one side of said two acoustic emission sensors, Close arrangement of said predetermined interval is vacated and carried out from an outer ring of spiral wound gasket which constitutes said bearing while coinciding another side of said two acoustic emission sensors with said one acoustic emission sensor and a hoop direction of said bearing, A substance excellent in sound propagation nature is made to intervene between said one acoustic emission sensor and said inner ring and between an acoustic emission sensor of said another side, and said outer ring of spiral wound gasket, It is recognized as said acoustic wave having occurred with parts close to an acoustic emission sensor which detected previously an acoustic wave which makes said damage a cause between said two acoustic emission sensors.

[0027]Anti-friction bearing is constituted by cage which generally holds an inner ring, an outer ring of spiral wound gasket, a rolling element (Collo or ball),

and a rolling element, and damage is generated in the either. For example, if damage occurs in the inner ring side, will spread it to an outer ring of spiral wound gasket via a rolling element an acoustic wave which makes it a cause not only spreads an inner ring, but, but. A time lag will arise between an acoustic wave which spreads an inner ring, and an acoustic wave spread to an outer ring of spiral wound gasket via a rolling element (a way of an acoustic wave which spreads an inner ring is detected previously). Then, in this invention, it is recognized as an acoustic wave which makes damage a cause with parts close to an acoustic emission sensor which detected previously an acoustic wave which makes damage a cause having occurred. It becomes possible to pinpoint roughly a generation place of an acoustic wave which makes damage a cause by performing such processing.

[0028]Near the bearing, a damage detection apparatus of the bearing according to claim 9 vacates an interval, and installs two acoustic emission sensors, It is a damage detection apparatus of a bearing which detects generating of damage in said bearing based on an output signal of this acoustic emission sensor, Close arrangement of the predetermined interval is vacated and carried out from an inner ring of spiral wound gasket which constitutes said bearing for one side of said two acoustic emission sensors, Close arrangement of said predetermined interval is vacated and carried out from an outer ring of spiral wound gasket which constitutes said bearing while coinciding another side of said two acoustic emission sensors with said one acoustic emission sensor and a hoop direction of said bearing, A substance excellent in sound propagation nature is made to intervene between said one acoustic emission sensor and said inner ring and between an acoustic emission sensor of said another side, and said outer ring of spiral wound gasket, It is recognized as said acoustic wave having occurred with parts close to an acoustic emission sensor which detected an acoustic wave which makes said damage a cause between said two acoustic emission sensors with a bigger signal level.

[0029]In a general bearing, if damage occurs in the inner ring side, will spread it to an outer ring of spiral wound gasket via a rolling element an acoustic wave which makes it a cause not only spreads an inner ring, but, but. A difference will arise in an output level of a signal in an acoustic wave which spreads an inner ring, and an acoustic wave spread to an outer ring of spiral wound gasket via a rolling element (a way of an output level which spreads an inner ring becomes high). Then, in this invention, it is recognized as an acoustic wave which makes damage a cause with parts close to an acoustic emission sensor which detected an acoustic wave which makes damage a cause with a bigger signal level having occurred. It becomes possible to pinpoint roughly a generation place of an acoustic wave which makes damage a cause by performing such processing.

[0030]A damage detection apparatus of the bearing according to claim 10 installs two or more acoustic emission sensors in a bearing or its neighborhood, It is a damage detection apparatus of a bearing which detects generating of damage in said bearing based on an output signal of this acoustic emission sensor, Whenever an acoustic wave which makes said damage a cause occurs, a generation place of this acoustic wave is pinpointed, It is recognized as an inner ring of spiral wound gasket which constitutes said bearing and is rotated with an axis when this generation place moves in connection with the passage of time with relative velocity of said inner ring of spiral wound gasket to said rolling element having been damaged, It is recognized as a rolling element which constitutes said bearing when a generation place of said acoustic wave moves at the rate of a half of revolving speed of said axis having been damaged, When a generation place of said acoustic wave does not move by the passage of time, either, it is recognized as an outer ring of spiral wound gasket which constitutes said bearing and is fixed to a regular position having been damaged.

[0031]In common anti-friction bearing, supposing an inner ring of spiral wound gasket is damaged, in connection with the passage of time, it will move to a hoop direction with an inner ring of spiral wound gasket, and the injured spot will

contact a rolling element allocated in a hoop direction one after another, and will generate an acoustic wave at every time. That is, since an inner ring of spiral wound gasket rotates with an axis, a generation place of an acoustic wave from which damage and a rolling element which were made moderately meet and happen will be moved with a speed equal to revolving speed of an axis.

[0032]Similarly, supposing an outer ring of spiral wound gasket is damaged, the injured spot will contact a rolling element which does not move, but is allocated in a hoop direction and moves in the direction one after another, and will generate an acoustic wave at every time. That is, a generation place of an acoustic wave from which damage and a rolling element which were made into an outer ring of spiral wound gasket meet and happen will be moved also by the passage of time.
[0033]Supposing a rolling element is damaged, moving to a hoop direction as well as an inner ring in connection with the passage of time, the injured spot will contact an inner ring and an outer ring of spiral wound gasket one after another, and will generate an acoustic wave at every time. That is, since a rolling element moves to a hoop direction, a generation place of an acoustic wave from which damage, and an inner ring and an outer ring of spiral wound gasket which were able to be done in a rolling element meet and happen will be moved to a direction of shaft rotation with a speed equal to a revolution speed (abbreviated 1 / 2 of family revolving speed) of a rolling element. Since it is explained by paragraph of 2.2 of Kogyo Chosakai Publishing Issue "antifriction bearing practical use handbook", and kinematics of a bearing in full detail, please refer to it for revolving speed of a cage and a rolling element specified to family revolving speed.
[0034]Then, in this invention, it recognizes which part of an inner ring which constitutes a bearing by at what kind of speed it moves when moving whether a generation place of an acoustic wave moves, an outer ring of spiral wound gasket, and a rolling element was damaged. By performing such processing, it becomes possible to pinpoint an injured spot roughly.
[0035]A damage detection apparatus of the bearing according to claim 11 installs two or more acoustic emission sensors in a bearing or its neighborhood, It is a damage detection apparatus of a bearing which detects generating of damage in said bearing based on an output signal of this acoustic emission sensor, One point of a hoop direction is set as each of an inner ring which constitutes said bearing, a cage holding a rolling element, and an outer ring of spiral wound gasket as a reference point, Whenever an acoustic wave which makes said damage a cause occurs, a generation place of this acoustic wave is pinpointed, A phase angle of a hoop direction from said reference point to a generation place of said acoustic wave is measured about each of said inner ring, a cage, and an outer ring of spiral wound gasket, and it is recognized as damage having occurred on parts from which said phase angle does not change among said inner ring, a cage, and an outer ring of spiral wound gasket.
[0036]It understands which part of an inner ring which constitutes a bearing by at what kind of speed it moves when moving whether a generation place of an acoustic wave moves, as mentioned above, an outer ring of spiral wound gasket, and a rolling element damaged. This can say a generation place of an acoustic wave with parts which are always regular positions having been damaged, if a view is changed. Then, in this invention, whenever an acoustic wave which makes damage a cause occurs, a phase angle of a hoop direction from a reference point to a generation place of an acoustic wave is measured, a phase angle does not change among an inner ring, a cage, and an outer ring of spiral wound gasket, i.e., it is recognized as damage having occurred on parts which a generation place of an acoustic wave does not move. By performing such processing, it becomes possible to specify which place of which part an injured spot is.
[0037]A damage detection apparatus of the bearing according to claim 12 installs two or more acoustic emission sensors in a bearing or its neighborhood, It is a damage detection apparatus of a bearing which detects generating of damage in

said bearing based on an output signal of this acoustic emission sensor, Two or more fields divided into a hoop direction about an inner ring which constitutes said bearing, a cage holding a rolling element, and each part article of an outer ring of spiral wound gasket are set up, Whenever an acoustic wave which makes said damage a cause occurs, a generation place of this acoustic wave is pinpointed by each area unit of said each part article, generating frequency of said acoustic wave is integrated for every pinpointed field, the number of accumulation is compared for every fields of all the, and a grade of advance of said damage in said each part article is judged.

[0038]Although many acoustic waves which make damage a cause in a certain field which includes an injured spot of parts applicable in an early stage when a certain part is damaged about one parts of an inner ring which constitutes a bearing, a cage, and an outer ring of spiral wound gasket occur especially, An acoustic wave which makes damage a cause in other fields of parts which produced damage when damage advanced with progress of time soon comes to occur, and if the number of accumulation of a generation place of an acoustic wave is compared in a field including a part damaged first and other fields, a difference for every field will tend to become small. On the other hand, about other parts which have not been damaged, an acoustic wave which makes damage a cause is distributed over all the fields also in a stage in which damage advanced even if it was an early stage, and is generated in it. In order that this may move other parts relatively to a certain parts, a generation place of an acoustic wave from which damage produced on a certain parts collides with other parts, and arises is because a place is made moved in connection with relative displacement of a certain parts speaking of other parts. Then, in this invention, a generation place of an acoustic wave is integrated for each [which was set as each part article which constitutes a bearing] field of every, the number of accumulation is compared for every fields of all the, and a grade of advance of damage in each part article is judged. It becomes possible to grasp how many the damage is advancing by performing such processing by damage arising which neighborhood of which parts which constitute a bearing.

[0039]

[Embodiment of the Invention]A 1st embodiment concerning this invention is shown in drawing 1 thru/or drawing 5, and is described. Drawing 1 is a top view of anti-friction bearing which supports pivotally the solid of revolution provided in a YUNGUSUTOROMU air preheater etc. Not only the thing of a graphic display but the anti-friction bearing 1 comprises the cage 5 which holds the inner ring 2 which rotates with the axis of a solid of revolution, the outer ring of spiral wound gasket 3 fixed to the stand (9; it illustrates to drawing 4) regular position, two or more Collo (rolling element) 4 which it is inserted among these inside-and-outside rings 2 and 3, and is rolled, and two or more Collo 4 at equal intervals.

[0040]In this invention, it will be the requisite to attach two or more acoustic emission sensors to a bearing like drawing 1. In how to attach an acoustic emission sensor, it can really be considered that the pattern of shoes attaches to IV stand between which the substance which detached and installed I acoustic emission sensor S from the III bearing which is directly attached to a bearing, and which is attached to II bearing via an interval piece, and was excellent in sound propagation nature between them is made to be placed. These attachment patterns may be combined and adopted, respectively.

[0041]As shown in drawing 2, acoustic emission sensor S equips the control surface 7 with the piezoelectric material 6 as an element which detects an acoustic wave, when attaching to the bearing 1 directly, applies the control surface 7 to the surface, and is attached. When attaching acoustic emission sensor S to the bearing 1 indirectly, as shown in drawing 3 (a), the interval piece 8 is made to intervene between the bearings 1, and the control surface 7 is applied to the interval piece 8, and it is attached. The construction material which the speed of polystyrene which spreads a sound is suitably slow, and has little attenuation is adopted as the interval piece 8. When constituted as an

integral-type acoustic emission sensor which pastes up the piezoelectric material 6 on the both ends of the interval piece 8, respectively, and has the two control surfaces 7, as shown in drawing 3 (b), one piezoelectric material 6 is applied to the surface of the bearing 1 or a stand, and it is attached. As shown in drawing 4 (a), when being detached and installed from the bearing 1, it is placed into the lubricating oil in which it is accumulated in stand 9 inside and the bearing 1 is dipped. In the case of the above-mentioned air preheater, since the bearing 1 is dipped in a lubricating oil, this is used. As shown in drawing 4 (b), also when direct attachment is carried out at the stand 9, the control surface 7 is applied to the surface, and it is attached.

[0042]Drawing 5 is a schematic diagram showing the damage detection apparatus of a bearing. This damage detection apparatus is provided with the following.
The two acoustic emission sensors S1, S2.
The signal processing part 10 which processes these output signals.
The acoustic wave which spreads the parts which constitute the bearing 1 for generating of damage detects these two acoustic emission sensors S1 and S2, and they vacate an interval for a hoop direction and are soon attached to the outer ring of spiral wound gasket 3.

[0043]In the above-mentioned damage detection apparatus, during operation of an air preheater, the acoustic emission sensor S1 and S2 detect continuously the acoustic wave generated in the bearing 1, a signal is outputted to the signal processing part 10, and the signal processing part 10 is performing processing which detects generating of damage based on the acoustic emission sensor S1 and the output signal of S2.

[0044]Here, when the acoustic emission sensor S1 processed in the signal processing part 10 and the output signal (HARASHIN item) of S2 are compared, as shown in drawing 6, the wave of a small cycle laps with the wave of a big cycle, and it turns out that the peak (change) of further some has appeared. It is thought that the peak which appeared to the same timing as two output signals is based on electrical noise, and it is thought that the peak which set the time lag and appeared is based on the acoustic wave generated in the bearing 1 by making damage into a cause.

[0045]In the signal processing part 10, processing which restricts frequency covering a band pass filter (100-500 kHz) over two output signals is performed, envelope detection is performed continuously, and the difference signal of an after-detection signal is created further. The after-detection signal of two and the difference signal created based on it are shown in drawing 7.

[0046]In the after-detection signal of two, both the peak by electrical noise and the peak by generating (this is called AE event) of the acoustic wave which makes damage a cause and by which it is accompanied have appeared clearly. It is outputted regularly [the output by background noise] on the level on which the bottom raising of the signal strength was carried out a little. However, after being processed into a difference signal, the output of the peak by the electrical noise which appeared to the same timing, or background noise was offset, and only the peak of AE event which set the time lag and appeared was divided into positive/negative, and it has appeared.

[0047]In the signal processing part 10, when such waveforms are detected, it is recognized as the acoustic wave which makes damage a cause having occurred in the bearing. Generating of damage can be detected by performing the above-mentioned processing, without being confused by electrical noise and background noise. However, since it is also considered that change by another factor is completely detected, a certain threshold is provided and only change exceeding this threshold is set for damage to the bearing 1 as the object of recognition.

[0048]Although this embodiment showed the two acoustic emission sensors S1 and the example which carried out direct attachment of S2 at the bearing 1, For example, direct attachment only of one acoustic emission sensor S1 may be carried out at the bearing 1, the interval piece 8 or a lubricating oil may be made to intervene, may be separated from the bearing 1, the acoustic emission sensor S2

of another side may be installed, and an integral-type acoustic emission sensor may be used like drawing 3 (b). Each of two acoustic emission sensors S1 and S2 is separated from the bearing 1, and direct attachment may be carried out and it may install in the stand 9 via a lubricating oil. However, since it distinguishes between the transfer time of an acoustic wave also in this case the two acoustic emission sensors S1 and S2, it is necessary to change the distance to the bearing 1. Although it had composition which installed the acoustic emission sensor S1 and S2 in the inside of the stand 9, and was dipped into the lubricating oil in this embodiment, you may install in the exterior of the stand 9. To install the acoustic emission sensor S1 and S2 in the inside of the stand 9, it is necessary to use the acoustic emission sensor which has an oil-repellent seal but, and to install in the exterior of the stand 9, such seal structures are unnecessary. And since an acoustic emission sensor is outside exposed, there is an advantage, like the check is attained also in operation.

[0049]Next, a 2nd embodiment concerning this invention is shown in drawing 8 and drawing 9, and is described. In the damage detection apparatus of this embodiment, as shown in drawing 8, the three acoustic emission sensors S1, S2, and S3 are estranged and installed in the hoop direction of the bearing 1 at equal intervals, The signal processing part 10 is performing processing which pinpoints the generation place of the acoustic wave which makes damage a cause while detecting generating of damage based on the output signal of the acoustic emission sensor S1, S2, and S3.

[0050]If the output signal (signal after covering a band pass filter) of the acoustic emission sensor S1 processed in the signal processing part 10, S2, and S3 is compared, as shown in drawing 9, It turns out that three output signals were alike, respectively, the big peak has appeared, and the time lag is further attached to those manifestations slightly. The three acoustic emission sensors S1 which estranged the acoustic wave which generated the same damage as a cause, and have been arranged, S2, and S3 this, It is the result of detecting including the delay (propagation time) proportional to the length of the distance from the generation place of damage, It is shown that the acoustic emission sensor S1 from which the acoustic emission sensor S2 which detected the acoustic wave first detected most the neighborhood to the generation place of the acoustic wave, and detected the acoustic wave to the second is close to the second to the generation place of an acoustic wave, and the acoustic emission sensor S3 which finally detected the acoustic wave is the furthest from the generation place of an acoustic wave. The peak which appeared without giving a time lag is based on electrical noise.

[0051]First, it is specified that the generation place of the acoustic wave which makes damage a cause for the information so far is between the acoustic emission sensor which detected the acoustic wave first, and the acoustic emission sensor which detected the acoustic wave to the second (i.e., between the acoustic emission sensor S1 and S2). The generation place of an acoustic wave is pinpointed from the time lag of the peak of the acoustic emission sensor S2, and the peak of the acoustic emission sensor S1. Specifically, it is specified from the acoustic emission sensor S1 and the halfway point of S2 that a place only with the distance of time lag x acoustic velocity / 2 near the first acoustic emission sensor S2 is a generation place of an acoustic wave.

[0052]Thus, in this embodiment, it can be exactly specified by observing the time lag at the time of the three acoustic emission sensors S1, S2, and S3 detecting an acoustic wave whether the acoustic wave which makes damage a cause where of the bearing 1 occurred.

[0053]These may be attached to the inner ring 2 or the cage 5 although the three acoustic emission sensors S1, S2, and S3 were attached to the outer ring of spiral wound gasket 3 fixed to the regular position in this embodiment. However, to carry out direct attachment of the acoustic emission sensor at these, it is necessary to constitute, since the inner ring of spiral wound gasket 2 and the cage 5 all rotate to the circumference of an axis so that information may be transmitted by a wireless communication means between each acoustic emission

sensor and the signal processing part 10. To estrange and install an acoustic emission sensor from the inner ring of spiral wound gasket 2 or the cage 5, it is necessary to make the substance excellent in sound propagation nature, such as a lubricating oil, intervene among both. The number of acoustic emission sensors may be not only more than three but it.

[0054]Next, a 3rd embodiment concerning this invention is shown in drawing 10 and drawing 11, and is described. As shown in drawing 10, in the damage detection apparatus of this embodiment the two acoustic emission sensors S1 and S2, If it sees from shaft orientations, it will be arranged in accordance with the hoop direction of the bearing 1, and further, one acoustic emission sensor S1 vacates the interval d for the control surface 7 to the inner ring 2, close arrangement is carried out, the acoustic emission sensor S2 of another side vacates the interval d for the control surface 7 as well as the acoustic emission sensor S1 to the outer ring of spiral wound gasket 3, and close arrangement is carried out. The two acoustic emission sensors S1 and S2 are placed into the lubricating oil in which the bearing 1 is dipped, and they are making the lubricating oil intervene between each control surface 7, and the target inner ring 2 and the outer ring of spiral wound gasket 3. Thereby, especially the acoustic emission sensor S1 detects the acoustic wave generated in the inner ring 2, and especially the acoustic emission sensor S2 detects the acoustic wave generated in the outer ring of spiral wound gasket 3. Based on the acoustic emission sensor S1 and the output signal of S2, the signal processing part 10 is performing processing which specifies whether the acoustic wave which makes damage a cause with which parts of the inner ring 2 and the outer ring of spiral wound gasket 3 occurred while detecting generating of damage.

[0055]When the acoustic emission sensor S1 processed in the signal processing part 10 and the output signal (signal after envelope detection) of S2 are compared, as shown in drawing 11, it turns out that two output signals were alike, respectively, the big peak has appeared, and the time lag is further attached to those manifestations slightly. This a certain acoustic wave which generated damage as a cause the two acoustic emission sensors S1 and S2, It is the result of detecting including the delay (propagation time) proportional to the length of the propagation path from the generation place of an acoustic wave, It is shown that the acoustic emission sensor S2 which the acoustic emission sensor S1 which detected the acoustic wave previously detected directly the parts which the acoustic wave generated, i.e., the acoustic wave which spread the inner ring 2, and detected the acoustic wave behind detected indirectly the acoustic wave which spread the inner ring 2 via Collo 4 and the outer ring of spiral wound gasket 3. Therefore, the acoustic wave which makes damage a cause is specified as the acoustic emission sensor which detected the acoustic wave previously occurred with the target parts 2, i.e., an inner ring of spiral wound gasket.

[0056]By the way, as drawing 11 shows, it turns out that the large and small difference is attached to the level of not only a time lag but output intensity at two peaks. This a certain acoustic wave which generated damage as a cause the two acoustic emission sensors S1 and S2, It is the result of detecting including attenuation proportional to the length of the propagation path from the generation place of damage, The parts on which damage generated the acoustic emission sensor S1 which detected the acoustic wave with the bigger output level, That is, it is shown that the acoustic emission sensor S2 which detected directly the acoustic wave which spread the inner ring 2, and detected the acoustic wave with the smaller output level detected indirectly the acoustic wave which spread the inner ring 2 via Collo 4 and the outer ring of spiral wound gasket 3. Therefore, the acoustic wave which makes damage a cause is specified as the acoustic emission sensor detected with the bigger output level generated this acoustic wave with the target parts 2, i.e., an inner ring of spiral wound gasket.

[0057]Thus, in this embodiment, it can be exactly specified by observing either the time lag at the time of the two acoustic emission sensors S1 and S2 detecting an acoustic wave, or the size of an output level whether damage occurred as which

of the inner ring 2 and the outer ring of spiral wound gasket 3.
[0058]Next, a 4th embodiment concerning this invention is described. In the damage detection apparatus of this embodiment, the art of pinpointing the generation place of the acoustic wave explained, for example by a 2nd embodiment of the above is used, and it is detected on which parts that constitute the bearing 1 damage occurred. The signal processing part 10 memorizes the generation place of an acoustic wave from change of the acoustic wave repeatedly detected in connection with the passage of time, and, specifically, is performing processing which specifies whether the inner ring 2, the outer ring of spiral wound gasket 3, and the acoustic wave that makes damage a cause with which parts of Collo 4 occurred by comparing them.
[0059]The damage to the bearing 1 is generated in most cases by bite lump of a foreign matter between the inner ring 2 and Collo 4 or between the outer ring of spiral wound gasket 3 and Collo 4. For example, supposing a foreign matter bites between the inner ring of spiral wound gasket 2 and Collo 4 and the inner ring of spiral wound gasket 2 is damaged, in connection with the passage of time, it will move to a hoop direction with the inner ring of spiral wound gasket 2, and the injured spot will contact Collo 4 allocated in the hoop direction one after another, and will produce an acoustic wave at every time. That is, since the inner ring of spiral wound gasket 2 rotates with an axis, the generation place of an acoustic wave from which the damage and each Collo 4 which were made in the inner ring of spiral wound gasket 2 meet and happen will be moved with a speed equal to the revolving speed of an axis.
[0060]Supposing a foreign matter bites between the outer ring of spiral wound gasket 3 and Collo 4 and the outer ring of spiral wound gasket 3 is damaged, the injured spot will contact each Collo 4 by which it is allocated in a hoop direction and where it does not move in, but it moves in the direction one after another, and will produce an acoustic wave at every time. That is, the damage and each Collo 4 which were made to the outer ring of spiral wound gasket 3 will not move the generation place of an acoustic wave which meets and happens by the passage of time, either.
[0061]Supposing a foreign matter bites between the inner ring 2 or the outer ring of spiral wound gasket 3, and Collo 4 and Collo 4 is damaged, moving to a hoop direction as well as the inner ring 2 in connection with the passage of time, the generation place will contact the inner ring 2 and the outer ring of spiral wound gasket 3 one after another, and will produce an acoustic wave at every time. That is, since Collo 4 moves to a hoop direction, the generation place of an acoustic wave from which damage, and the inner ring 2 and the outer ring of spiral wound gasket 3 which were able to be done in Collo 4 meet and happen will be moved to a direction of shaft rotation with a speed equal to the revolution speed (being the revolving speed of the cage 5 abbreviated 1 / 2 of the revolving speed of the inner ring 2) of Collo 4.
[0062]Then, if the generation place of an acoustic wave is moving with a speed equal to the relative velocity of the inner ring of spiral wound gasket 2 to Collo 4, It is specified that the inner ring 2 was damaged, and if the generation place of an acoustic wave is moving with a speed equal to the revolving speed of Collo 4, it will be specified that Collo 4 was damaged and the generation place of an acoustic wave will not move, it is specified that the outer ring of spiral wound gasket 3 was damaged.
[0063]Thus, in this embodiment, it can be exactly specified by memorizing the generation place of an acoustic wave temporally and comparing the method of the change whether damage occurred as any of the inner ring 2, the outer ring of spiral wound gasket 3, and Collo 4.
[0064]Next, a 5th embodiment concerning this invention is described. In the damage detection apparatus of this embodiment, the art of pinpointing the generation place of the acoustic wave explained, for example by a 2nd embodiment of the above, and the art of specifying the damaged parts which were explained by a 3rd embodiment of the above are used, and it is detected where of which part that constitute the bearing 1 damage occurred. The signal processing part 10

specifically sets one point of a hoop direction as each holding the inner ring 2 which constitutes the bearing 1, the outer ring of spiral wound gasket 3, and Collo 4 of the cage 5 as a reference point, Whenever an acoustic wave occurs, the phase angle of the hoop direction from a reference point to the generation place of an acoustic wave is measured about each of the inner ring 2, the outer ring of spiral wound gasket 3, and the cage 5, He is trying to recognize it as damage having occurred on the parts (when it is the cage 4, Collo 4 held at this is also included) from which a phase angle does not change among the inner ring 2, the outer ring of spiral wound gasket 3, and the cage 5.

[0065]It understands whether the parts of the inner ring 2, the outer ring of spiral wound gasket 3, and the cage 5 (Collo 4) throat were damaged by at what kind of speed as mentioned above, when moving whether the generation place of an acoustic wave moves, it moves. This can say the generation place of an acoustic wave with the parts which are always regular positions having been damaged, if a view is changed.

[0066]Then, the phase angle of the hoop direction from the reference point beforehand set up about each of the inner ring 2, the outer ring of spiral wound gasket 3, and the cage 5 whenever the acoustic wave occurred in the bearing 1 to the generation place of an acoustic wave is measured, When a phase angle does not change about the inner ring 2, it is specified that the inner ring 2 was damaged, when a phase angle does not change similarly about the outer ring of spiral wound gasket 3, it is specified that the outer ring of spiral wound gasket 3 was damaged, and when a phase angle does not change similarly about the cage 5, it is specified that Collo 4 held at the cage 5 or this was damaged.

[0067]Thus, in this embodiment, it can be exactly specified by memorizing the generation place of an acoustic wave temporally about each of the inner ring 2, the outer ring of spiral wound gasket 3, and the cage 5, and comparing the method of the change whether damage occurred where of which part that constitute the bearing 1.

[0068]Next, a 6th embodiment concerning this invention is shown in drawing 12 and drawing 13, and is described. In the damage detection apparatus of this embodiment, the art of pinpointing the generation place of the acoustic wave explained, for example by a 2nd embodiment of the above, and the art of specifying the damaged parts which were explained by a 3rd embodiment of the above are used, and it is detected where of which part that constitute the bearing 1 the acoustic wave occurred. For every each part article of the inner ring 2 which constitutes the bearing 1, the outer ring of spiral wound gasket 3, and the cage 5. Two or more fields R1-R6 divided into a hoop direction as shown in drawing 12 are set up, It specifies by each area unit of R1-R6 which set the generation place as each part article whenever the acoustic wave occurred, and the generating frequency of an acoustic wave is counted for every pinpointed field (addition), the count number (the number of accumulation) is compared for every fields of all the, and the grade of advance of the damage in each part article is judged.

[0069]By drawing 13, the count number for every field in an early stage is compared with the count number for every field in the stage in which damage advanced about a certain parts in which damage occurred. Although many acoustic waves which make damage a cause in the field R3 considered that damage broke out occur especially in an early stage, The acoustic wave which will make damage a cause in other fields if damage advances with progress of time comes to occur, and if the count number of the generation place of an acoustic wave is compared in the field R3 where damage broke out first, and other fields, the difference for every field will tend to become small. On the other hand, about other parts which have not been damaged, the acoustic wave which makes damage a cause is distributed over all the fields also in the stage in which damage advanced even if it was an early stage, and is generated in it. In other words, it projects to a certain field and generating of damage does not count.

[0070]Then, if there are parts with which project to a certain field and generating of damage is first accepted to be, damage should arise on the parts

and in a field and other fields with still more [part / the] count numbers of an acoustic wave. The difference of a count number is searched for, if a difference is large, it is in the stage in early stages of damage, and if a difference is small, it will judge with it being in the stage in which damage advanced. In this case, it is desirable to distinguish the difference searched for according to some thresholds, and to judge the grade of advance gradually.

[0071]Thus, in this embodiment, the generation place of an acoustic wave is counted every field of R1-R6 which were set as each part article which constitutes the bearing 1, a count number is compared for every fields of all the, and the grade of advance of the damage in each part article is judged. It can grasp how many the damage is advancing by performing such processing by damage arising which neighborhood of which parts which constitute the bearing 1.

[0072]Next, a 7th embodiment concerning this invention is shown in drawing 14, and is described. In the damage detection apparatus of this embodiment, the art of judging the grade of advance of damage of having explained by a 6th embodiment of the above is used, and the state of damage is judged in more detail. The table which established the standard required for a damage judging is shown in drawing 14. In this reference table, <TXFFR=0001 HE=250 WI=080 LX=0200 LY=0300>intensity of distribution of the generation place of an acoustic wave, a count number, and an acoustic wave is made into the judgment item.
[0073]And if the generation place of the acoustic wave is carrying out localization (it is existence to a certain field mostly) to the inner ring of spiral wound gasket 2, for example, there are few count numbers and the intensity of an acoustic wave is small, It is judged with initial damage having occurred in the inner ring 2, for example, the generation place of the acoustic wave is carrying out localization to the outer ring of spiral wound gasket 3, and if the intensity of an acoustic wave is large, It is judged with it being in the stage in which the damage which occurred in the outer ring of spiral wound gasket 3 advanced, for example, the generation place of the acoustic wave is carrying out localization to the cage 5, and if there are many count numbers, it will be judged with damages to two or more having taken place in Collo 4.
[0074]The generation place of an acoustic wave is distributed over all the fields, and if there are many count numbers, it will be judged with damage having attained to the bearing 1 whole. Thus, in this embodiment, it is judging based on the above standards, and it becomes possible to grasp the faulted condition of a bearing.
[0075]
[Effect of the Invention]As explained above, according to this invention, a difference signal is created about each output signal of two acoustic emission sensors, When change exceeding the threshold in the difference signal is detected, generating of the acoustic wave which makes damage a cause can be correctly detected by recognizing it as the acoustic wave which makes damage a cause having occurred in the bearing, without being confused by electrical noise and background noise.
[0076]By recognizing it as the acoustic wave which makes damage a cause having occurred in the bearing, when according to this invention a time lag was individually set by two or more acoustic emission sensors and change of an output was detected, Generating of the acoustic wave which makes damage a cause can be detected correctly, without being confused by electrical noise and background noise.
[0077]According to this invention, the generation place of the acoustic wave which makes damage a cause can be roughly pinpointed by recognizing it as the acoustic wave which makes said damage a cause between the acoustic emission sensor which detected the acoustic wave first, and the acoustic emission sensor detected to the second having occurred.
[0078]According to this invention, the generation place of the acoustic wave which makes damage a cause can be roughly pinpointed by recognizing it as the

acoustic wave which makes damage a cause with the parts close to the acoustic emission sensor which detected previously the acoustic wave which makes damage a cause having occurred.
[0079]According to this invention, the generation place of the acoustic wave which makes damage a cause can be roughly pinpointed by recognizing it as the acoustic wave which makes damage a cause with the parts close to the acoustic emission sensor which detected the acoustic wave which makes damage a cause with the bigger signal level having occurred.
[0080]According to this invention, an injured spot can be roughly pinpointed by recognizing which part of the inner ring which constitutes a bearing by at what kind of speed it moves when moving whether the generation place of an acoustic wave moves, the outer ring of spiral wound gasket, and the rolling element was damaged.
[0081]According to this invention, the phase angle of the hoop direction from the reference point beforehand set up about each of the inner ring, the cage, and the outer ring of spiral wound gasket to the generation place of an acoustic wave is measured, It can be specified which place of which part an injured spot is by recognizing it as damage having occurred on the parts which the generation place of an acoustic wave does not move among an inner ring, a cage, and an outer ring of spiral wound gasket.
[0082]According to this invention, the faulted condition of a bearing can be grasped by [which set it as the bearing] counting the generation place of an acoustic wave for every field, comparing the count number for every field, and judging the grade of advance of damage.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]It is a figure showing a 1st embodiment concerning this invention, and is a sectional view showing the structure of anti-friction bearing which is the target of damage detection.
[Drawing 2]It is a perspective view showing the structure of an acoustic emission sensor.
[Drawing 3]It is a figure showing how to attach the acoustic emission sensor to a bearing.
[Drawing 4]It is a figure showing how to attach the acoustic emission sensor to a bearing similarly.
[Drawing 5]It is a figure showing the composition of the damage detection apparatus of this embodiment.
[Drawing 6]It is a figure showing the waveform of the output signal of each acoustic emission sensor.
[Drawing 7]It is a figure showing the waveform of the after-detection signal of each acoustic emission sensor, and the waveform of the difference signal based on this after-detection signal.
[Drawing 8]It is a figure showing a 2nd embodiment concerning this invention, and is a figure showing the composition of a damage detection apparatus provided with three acoustic emission sensors.
[Drawing 9]It is a figure showing the waveform of the output signal of each acoustic emission sensor.
[Drawing 10]It is a figure showing a 3rd embodiment concerning this invention, and is a figure showing arrangement of the acoustic emission sensor to a bearing.

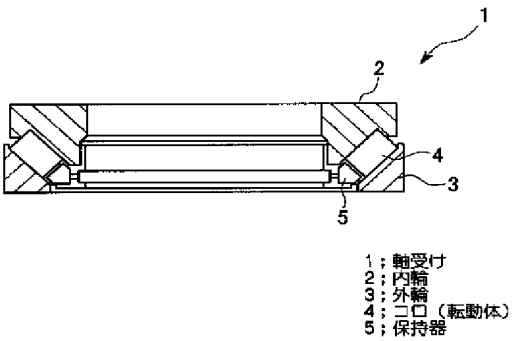
[Drawing 11]It is a figure showing the waveform of the after-detection signal of each acoustic emission sensor.
[Drawing 12]It is a figure showing a 6th embodiment concerning this invention, and is a figure showing the field which divided equally and set the bearing as

the hoop direction.
[Drawing 13]It is with the initial stage of damage, and the stage in which damage advanced, and is a figure showing the result of having counted generating of the acoustic wave and having totaled for every field.
[Drawing 14]It is a figure showing a 7th embodiment concerning this invention, and is a reference table for judging the grade of damage advance.

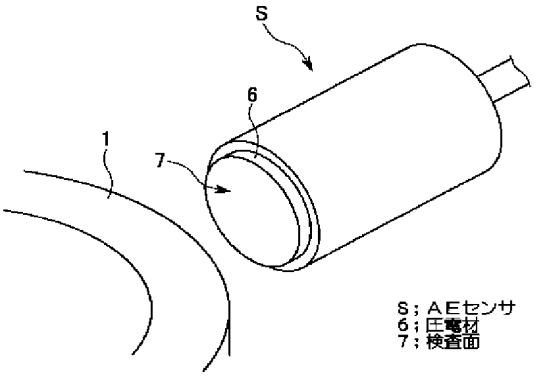
[Description of Notations]
1 Bearing
2 Inner ring of spiral wound gasket
3 Outer ring of spiral wound gasket
4 Collo (rolling element)
5 Cage
8 Interval piece
10 Signal processing part

DRAWINGS

[Drawing 1]

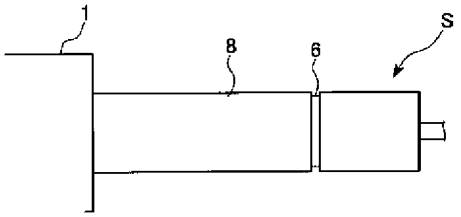


[Drawing 2]

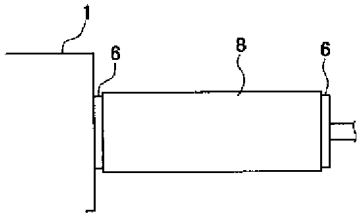


[Drawing 3]

(a)



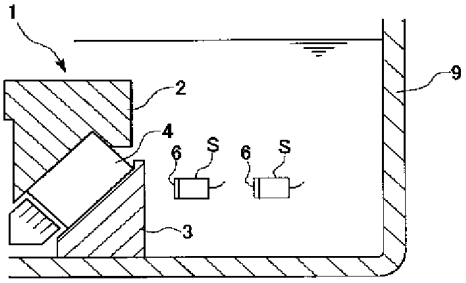
(b)



S；ＡＥセンサ
8；間隔片

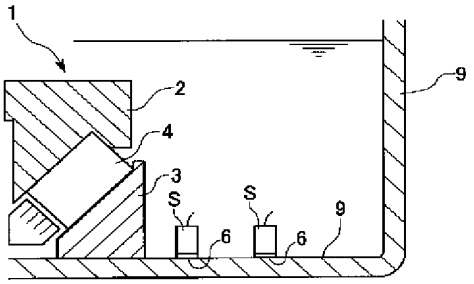
[Drawing 4]

(a)

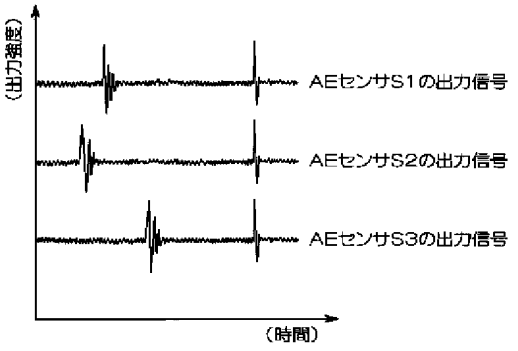


2；内輪
3；外輪
9；架台
S；ＡＥセンサ

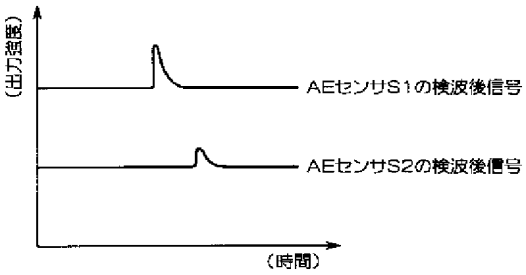
(b)



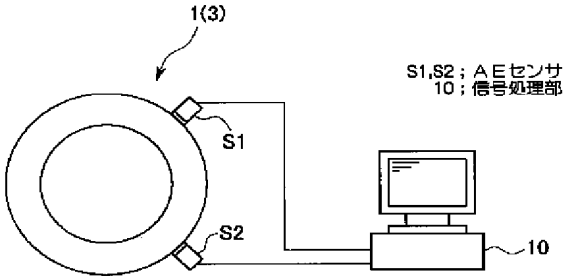
[Drawing 9]



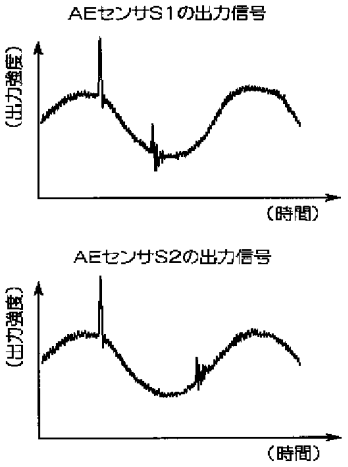
[Drawing 11]



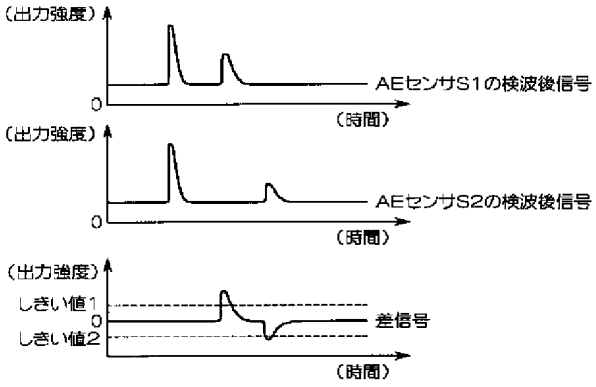
[Drawing 5]



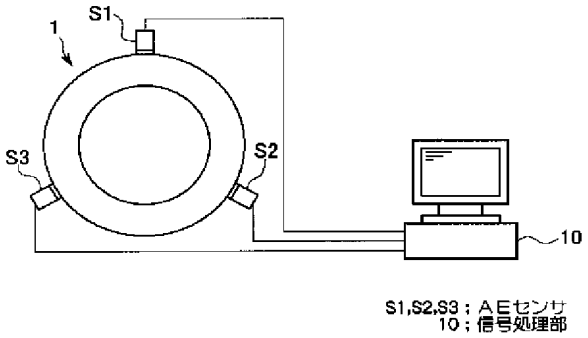
[Drawing 6]



[Drawing 7]

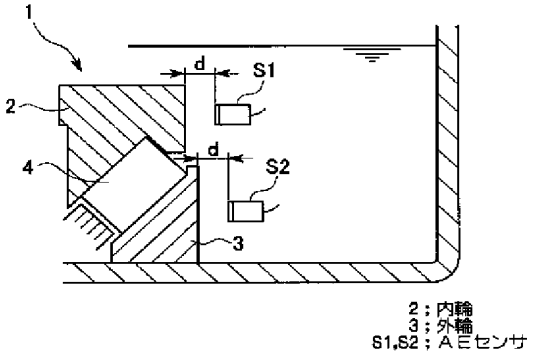


[Drawing 8]



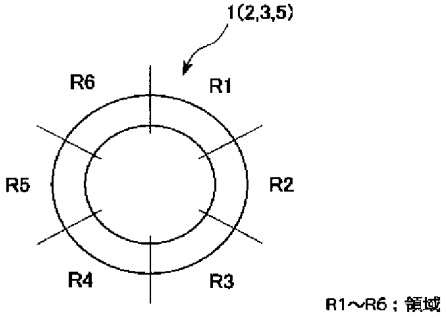
S1,S2,S3；ＡＥセンサ
10；信号処理部

[Drawing 10]



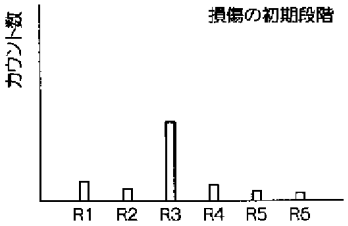
2；内輪
3；外輪
S1,S2；ＡＥセンサ

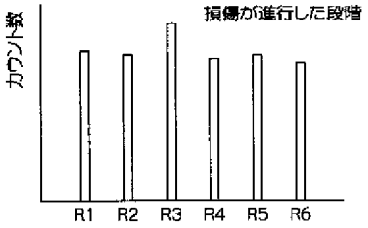
[Drawing 12]



R1～R6；領域

[Drawing 13]





[Drawing 14]

損傷進行の判定基準

損傷の種別	発生箇所の分布	カウント数	音響波の強度
内輪に初期の損傷	内輪に局在	少ない	小さい
外輪に初期の損傷	外輪に局在	少ない	小さい
コロに初期の損傷	保持器に局在	少ない	小さい
内輪に進行した損傷	内輪に局在	−	大きい
外輪に進行した損傷	外輪に局在	−	大きい
コロに進行した損傷	保持器に局在	−	大きい
内輪に複数の損傷	内輪に局在	多い	−
外輪に複数の損傷	外輪に局在	多い	−
コロに複数の損傷	保持器に局在	多い	−
軸受け全体に損傷が進展	全体に分布	多い	−

⑲日本国特許庁（JP）　⑪特許出願公開

⑫公開特許公報（A）　平3－177080

⑤1Int.Cl.[5]　識別記号　庁内整理番号　⑬公開　平成3年(1991)8月1日

H 01 L 33/00　E　8934－5F

審査請求　未請求　請求項の数 1　（全4頁）

⑤4発明の名称　発光ダイオードアレー

⑳特　願　平1－314296

㉒出　願　平1(1989)12月5日

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明細書

1．発明の名称

発光ダイオードアレー

2．特許請求の範囲

半導体基板と、該半導体基板の片面側の所定領域に形成された複数個の発光部と、夫々の該発光部と対向する前記半導体基板の他面側の位置に設けられた複数個の第1電極と、前記半導体基板の片面側から他面側に貫通して穿設された複数個の貫通孔と、該貫通孔の内周面と前記半導体基板の片面及び他面の所定領域に亘って被着された絶縁膜と、該絶縁膜上に形成され一端部を前記発光部に接続すると共に前記貫通孔を貫通して前記他面側に他端部を第2電極として延出した導体層とを具備することを特徴とする発光ダイオードアレー。

3．発明の詳細な説明

［産業上の利用分野］

本発明は、発光ダイオードアレーに関する。

［従来の技術］

発光ダイオードアレーは、プリンタやファクシミリ等のOA機器の感光用の光源に使用されている。このような発光ダイオードアレーとして、例えば、GaAs系の混晶半導体基板の主面中央部にその長手方向に沿って等間隔で連続的に所定の不純物領域を形成してp－n接合を作成し、これによって発光ドットを構成したものが使用されている。第3図は、従来の発光ダイオードアレーの要部の構成を示す平面図である。図中1は、発光ダイオードアレーチップである。発光ダイオードアレーチップ1は、ダイボンディング基板2上に等間隔で複数個配列され、光プリンター用発光ドットアレーを構成している。各々の発光ダイオードアレーチップ1は、金線等からなるボンディング線3介してプリント配線を構成するパッド4に接続されている。パッド4は、ドライビングIC5に接続している。

［発明が解決しようとする課題］

しかしながら、上述のように構成された従来の発光ダイオードアレーは、発光ダイオードアレーチップ1の一づつを、ボンディング線3によって

プリント配線のパッド４に接続している。このため、ボンディング回数が非常に多くなる。しかも、発光ダイオードアレーの集積度が高くなると、ボンディング回数が増すだけでなく、発光ダイオードアレーチップ１の相互間のスペースが狭くなり、自動ワイヤボンディング装置を使用できなくなる。更に、ワイヤボンディングのために、相当大きな電極取用パッドを必要とし発光部の面積に比較して、必要以上に広い面積の基板を必要とする問題があった。

本発明は、かかる点に鑑みてなされたものであり、ワイヤボンディングを不要にして製造が容易であり、しかも、集積度の向上を図った発光ダイオードアレーを提供するものである。

［課題を解決するための手段］

本発明は、半導体基板と、該半導体基板の片面側の所定領域に形成された複数個の発光部と、夫々の該発光部と対向する前記半導体基板の他面側の位置に設けられた複数個の第１電極と、前記半導体基板の片面側から他面側に貫通して穿設された複数個の貫通孔と、該貫通孔の内周面と前記半導体基板の片面及び他面の所定領域に亘って被着された絶縁膜と、該絶縁膜上に形成され一端部を前記発光部に接続すると共に前記貫通孔を貫通して前記他面側に他端部を第２電極として延出した導体層とを具備することを特徴とする発光ダイオードアレーである。

［作用］

本発明にかかる発光ダイオードアレーによれば、片面側に複数個の発光部を形成した半導体基板の他面側に、夫々の発光部と対向する複数個の第１電極を設け、かつ、半導体基板の片面側から他面側に貫通する貫通孔を穿設すると共に、一端部で発光部と接続する導体層を貫通孔を介して半導体基板の片面側から他面側に延出して第２電極を構成している。この結果、ワイヤボンディングを不要にして製造が容易であり、しかも、集積度の向上を達成できる。

［実施例］

以下、本発明の一実施例について図面を参照して説明する。

第１図は、本発明の実施例の発光ダイオードアレーの構造をその製造工程に沿って示す説明図である。

まず第１図（Ａ）に示す如く、主面側に所定の深さでＮ－ＧａＡｓＰ層１０を形成したＧａＡｓ基板１１を用意する。次いで、Ｎ－ＧａＡｓＰ層１０の表面にＰ－ＣＶＤ（Plasma-Chemical Vapor Deposition）法により、所定厚さのＳｉＮ層１２を形成する。このＳｉＮ層１２上に所定パターンのレジスト膜１３を形成する。

次に第１図（Ｂ）に示す如く、レジスト膜１３をマスクにして写真蝕刻法により、ＳｉＮ層１２の所定領域に拡散用の窓１４を開口する。次いで窓１４を介してＴｅ等の不純物を熱拡散して、Ｎ－ＧａＡｓＰ層１０内にその主面から所定の拡散深さで延在するＰ－ＧａＡｓＰ層１５を形成する。

次に第１図（Ｃ）に示す如く、窓１４を介して露出したＰ－ＧａＡｓＰ層１５を含むＳｉＮ層１２上に金属層１６を蒸着によって形成する。次いで、マスク合わせ工程とドライエッチング工程を経て金属層１６のパターニングを行う。

次に、第１図（Ｄ）に示す如く、ＧａＡｓ基板１１の裏面側にグラインディング研磨を施し、その厚さを３５０μｍから１５０μｍ、まで薄くする。

次に第１図（Ｅ）に示す如く、金属層１６及び、窓１４を介して露出したＰ－ＧａＡｓＰ層１５を含むＳｉＮ層１２を覆うレジスト膜１７を形成する。次いで、それぞれのＰ－ＧａＡｓＰ層１５間の領域に対応したレジスト膜１７の部分に、ドライエッチングにより、ＳｉＮ層１２の表面を露出するコンタクトホール１８を開口する。

次に第１図（Ｆ）に示す如く、レジスト膜１７をマスクにして、エッチングによりＳｉＮ層１２、Ｎ－ＧａＡｓＰ層１０、ＧａＡｓ基板１１を順次貫通して基板１０、１１の表面側から裏面側に及ぶ貫通孔１９を穿設する。エッチング液としては、例えば酒石酸溶液：H_2O_2＝１：１からなるも

のを使用する。

次に第１図（Ｇ）に示す如く、Ｐ－ＣＶＤ法により、基板１０、１１等の露出表面全体を覆う厚さ５μｍの絶縁膜２０を形成する。

次に第１図（Ｈ）に示す如く、リフトオフ法によりレジスト膜１７とのその上に被着された絶縁膜２０とを一体に除去する。

次に第１図（Ｉ）に示す如く、露出したＳｉＮ層１２、Ｐ－ＧａＡｓＰ層１５、金属層１６及び絶縁膜２０で覆われたコンタクトホール１８内と、裏面側の絶縁膜２０の表面にアルミニウム層２１を蒸着によって形成する。次いで、エッチング処理によって表面側には、金属層１６と接続してコンタクトホール１８内の絶縁膜２０上に残存するアルミニウム層２１を形成し、裏面側には、コンタクトホール１８内から導出したアルミニウム層２１で形成される所定パターンのＰ電極２２と、Ｐ－ＧａＡｓＰ層１５の直下の領域に残存するＮ電極２３とを形成する。

このように構成された発光ダイオードアレー３０は、第２図（Ａ）にアレーチップの一部を示すが、基板１１の裏面側の同一平面内にその長手方向に沿って、Ｐ電極２２とＮ電極２３を所定間隔で順次配列している。これらのアレーチップを実装する配線基板の例を第２図（Ｂ）に示す。アレーチップを、第２図（Ｂ）の配線基板上、つまりＰ電極２２に対応する電極２２´、そしてＮ電極に対応する電極２３´をもつ基板上に接触させ配線する。ここで、電極２２´２３´は、勿論で電機的に絶縁されている。

この結果、このようにこの発光ダイオードアレー３０によれば、基板１０、１１の表面側から裏面側に貫通する貫通孔１９が設けられ、一端部で発光部と接続したＰ電極２２が、この貫通孔１９を介して表面側から裏面側に延出し、Ｎ電極の平面と同一の平面内に配置されている。このため、従来必要としたワイヤボンディングを不要にして、発光ダイオードアレー３０の製造をが容易にできると共に、集積度を著しく向上させることができる。

［発明の効果］

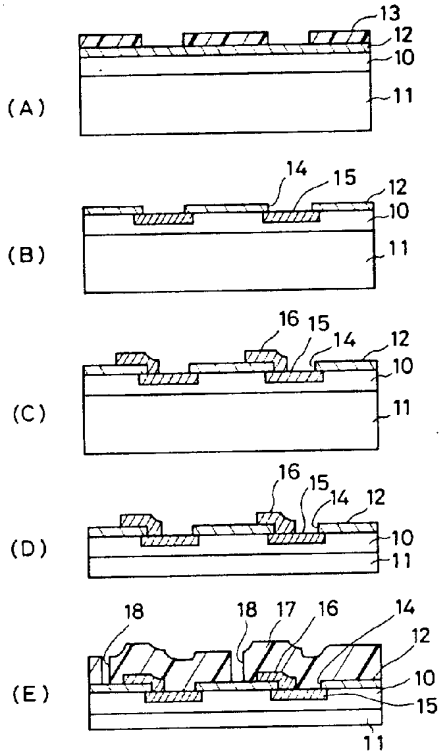
以上説明した如く、本発明にかかる発光ダイオードアレーによれば、ワイヤボンディングを不要にして製造が容易であり、しかも、集積度の向上を達成できる等顕著な効果を有するものである。

４．図面の簡単な説明

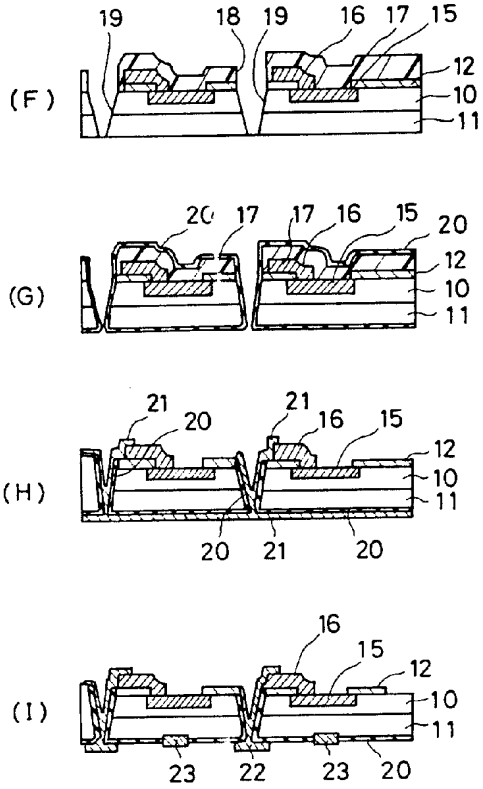
第１図は、本発明の実施例の発光ダイオードアレーの構造をその製造工程に沿って示す説明図、第２図は、同実施例の発光ダイオードアレーの裏面側及び方面側を示す説明図、第３図は、従来の発光ダイオードアレーの要部の構成を示す平面図である。

１０…Ｎ－ＧａＡｓＰ層、１１…ＧａＡｓ基板、１２…ＳｉＮ層、１３…レジスト膜、１４…窓、１５…Ｐ－ＧａＡｓＰ層、１６…金属層、１７…レジスト膜、１８…コンタクトホール、１９…貫通孔、２０…絶縁膜、２１…アルミニウム層、２２…Ｐ電極、２３…Ｎ電極、３０…発光ダイオードアレー。

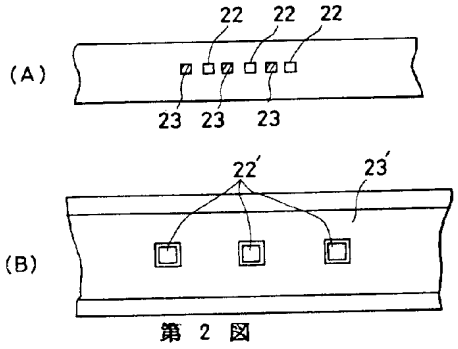
出願人代理人　弁理士鈴江武彦



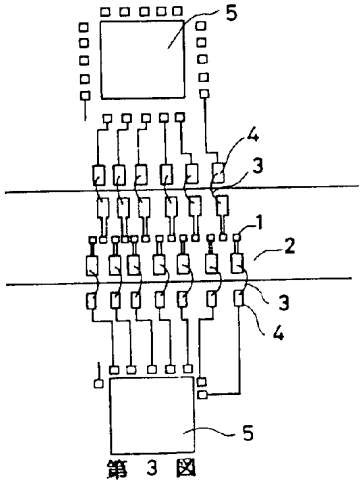
第 1 図



第 1 図



第 2 図



第 3 図